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FTDM-3177  
15 April 1964

437881

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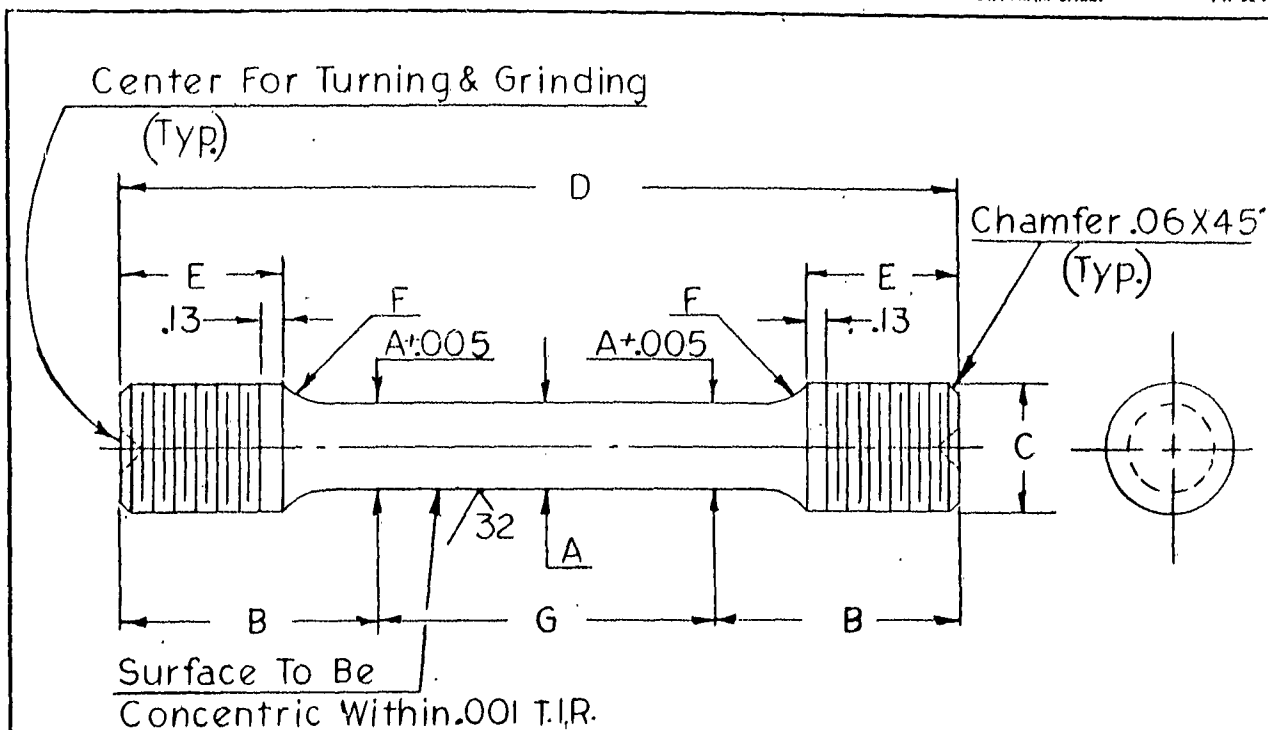
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437881

MATERIAL EVALUATION OF H-11 HIGH  
STRENGTH STEEL FOR F-111

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GENERAL DYNAMICS | FORT WORTH



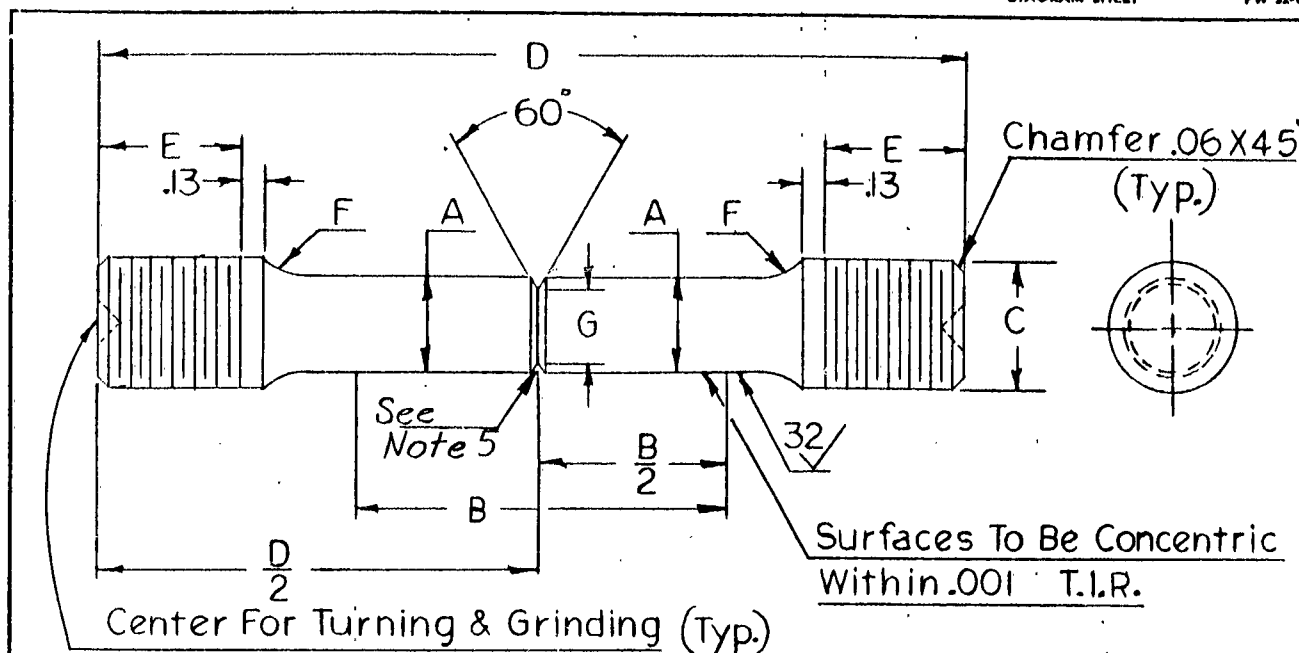
1. Unless otherwise specified tolerances are as follows:  
 Linear dimensions - .xx  $\pm$  .03 .xxx  $\pm$  .010  
 Angular  $\angle$  0° - 30°
2. Material to be as specified.
3. Grain direction to be longitudinal unless otherwise specified.

Figure 1.

Dash No	A	B	C	D	E	F (Min)	G (Gage Length)	
- 1	.505 ± .010	1.50	3/4 - 10 NC	5.00	1.00	.38	2.000 ± .005	
- 2	.357 ± .007	1.30	5/8 - 11 NC	4.00	.88	.25	1.400 ± .005	
- 3	.252 ± .005	1.06	1/2 - 13 NC	3.12	.75	.19	1.000 ± .005	
- 4	.200 ± .004	.85	5/16 - 24 NF	2.50	.63	.13	.800 ± .005	
DRAWN	R. Cathey		TENSILE TEST SPECIMEN - ROUND				FTJ - 10940	
CHECKED	R. Cathey						3/17/59	Full Scale
ENG.								
PROJECT			CONSOLIDATED VULTEE AIRCRAFT CORPORATION FORT WORTH DIVISION - FORT WORTH, TEXAS					

ISSUED:

REVISED:



## NOTES:

1. Unless otherwise specified tolerances are as follows:  
 Linear dimensions - .xx  $\pm$  .03 .xxx  $\pm$  .010  
 Angular dimensions -  $\pm$  0° - 30°
2. Material to be as specified.
3. Grain direction to be longitudinal unless otherwise specified.
4. Fabricate in accordance with the following procedure:
  - 4.1 Center ends & remove all burrs - center holes must be concentric
  - 4.2 Rough machine to 0.020 in. oversize omitting the notch.
  - 4.3 Heat treat as required.
  - 4.4 Machine or grind to finished dimensions except notch.
  - 4.5 Machine notch to .020 in. oversize using a carbide tool & lard oil coolant.
  - 4.6 Sharpen carbide tool to required size and finish machine notch.
  - 4.7 Examine notch under a microscope for surface smoothness and correct contour.

Dash No.	Notch Dia. (G)	Notch Radius	K <sub>2</sub> (max)	K <sub>1</sub> (min)
-5	.505	.005 $\pm$ .001	6.9	5.7
-6	.357	.003 $\pm$ .0015	8.0	5.5
-7	.252	.002 $\pm$ .0005	8.0	5.7

Figure 2.

Dash No	A	B	C	D	E	F	G
-5	.712	2.25	3/4 10 NC	5.00	1.00	.38	.505 $\pm$ .010
-6	.505	2.25	5/8 11 NC	4.50	.88	.25	.357 $\pm$ .007
-7	.357	1.25	1/2 13 NC	3.13	.75	.19	.252 $\pm$ .005

DRAWN	R. Carley	DATE		TENSILE SPECIMEN - NOTCHED	FTJ-10940
CHECKED					Scale - Full
ENG.					
PROJECT					

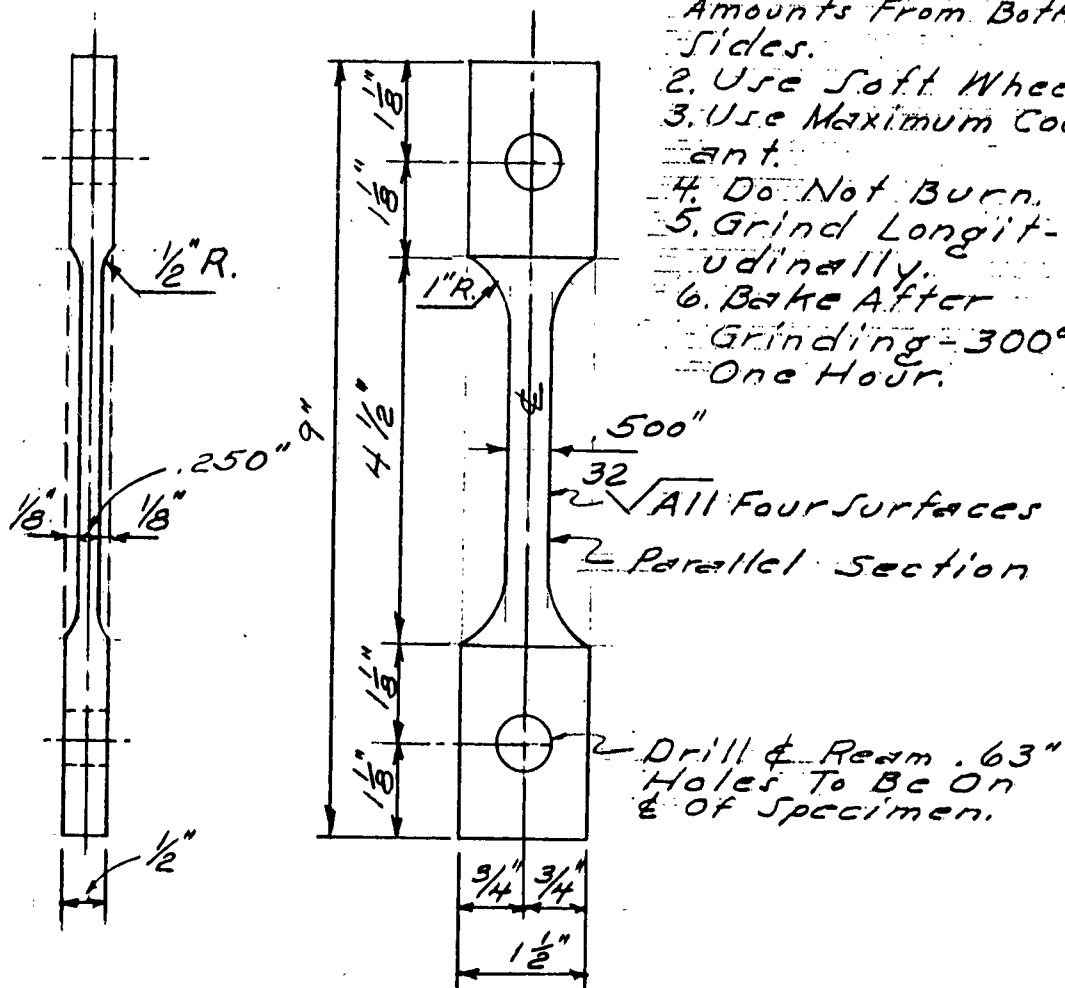
ISSUED:		REVISED:	
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CONSOLIDATED VULTEE AIRCRAFT CORPORATION  
 FORT WORTH DIVISION - FORT WORTH, TEXAS



GENERAL DYNAMICS | FORT WORTH

PAGE 4  
REPORT NO. FDM 3177  
MODEL F-111  
DATE 5 February 1964



- Grinding Notes
1. Remove Equal Amounts From Both Sides.
  2. Use Soft Wheel.
  3. Use Maximum Coolant.
  4. Do Not Burn.
  5. Grind Longitudinally.
  6. Bake After Grinding - 300°F. One Hour.

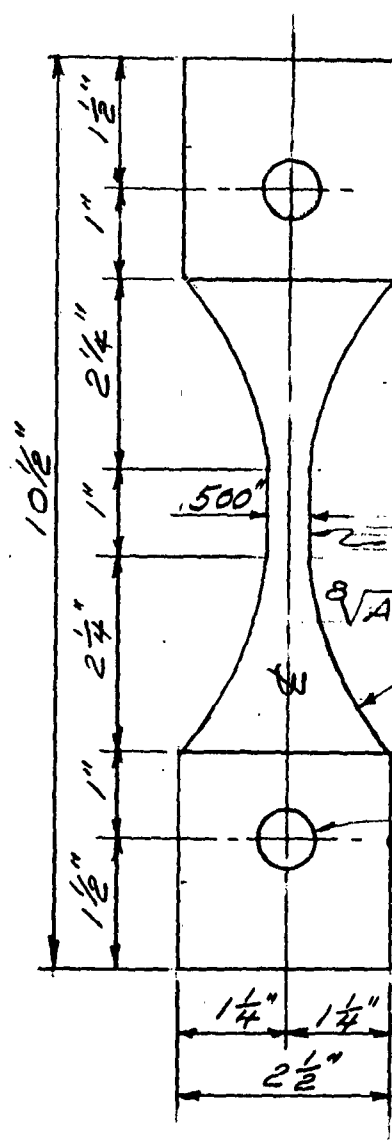
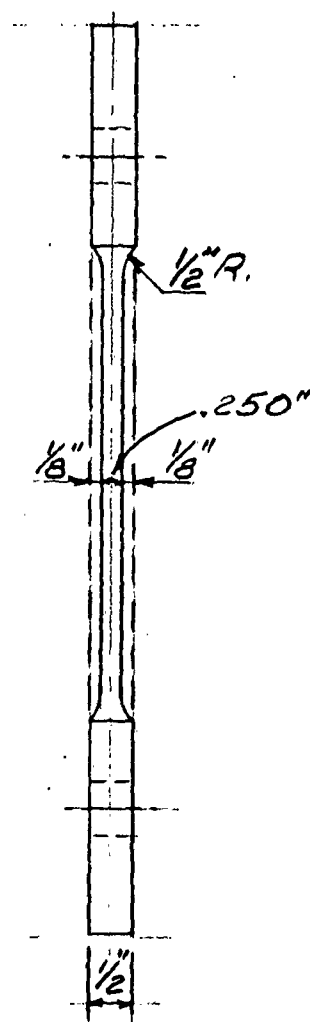
Transverse Weld Tensile Specimen  
From 1/2" Plate

Figure 3



GENERAL DYNAMICS | FORT WORTH

PAGE 5  
REPORT NO. FDM 3177  
MODEL F-111  
DATE 5 February 1964



### Grinding Notes

1. Remove Equal Amounts From Both Sides.
2. Use Soft Wheel & Maximum Coolant.
3. Do Not Burn.
4. Grind Longitudinally.
5. Bake After Grinding - 300°F. One Hour.

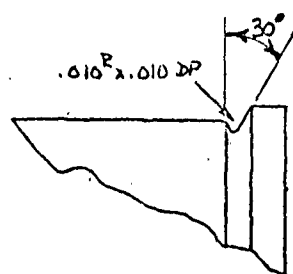
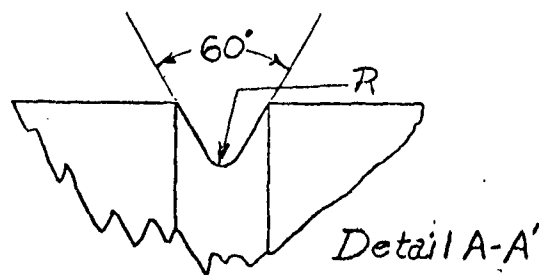
Parallel Section.

All Four Surfaces 3" R.

Drill & Ream .625" Holes To Be On E of Specimen.

Transverse Weld Fatigue Specimen  
From 1/2" Plate

Figure 4.



DASH NO	$K_t$	C $\pm .005$	D $\pm .005$	R $\pm .001$
-91	2	.430	.300	.049
-92	3	.430	.300	.016
-93	4	.430	.300	.008
-94	2	.357	.252	.037
-95	3	.357	.252	.013
-96	5	.357	.252	.004

NOTES:

- 1) Turn on centers.
- 2) Allow .020 on dias, for heat treat.
- 3) Not run after heat treat
- 4) Polish notch in lathe.

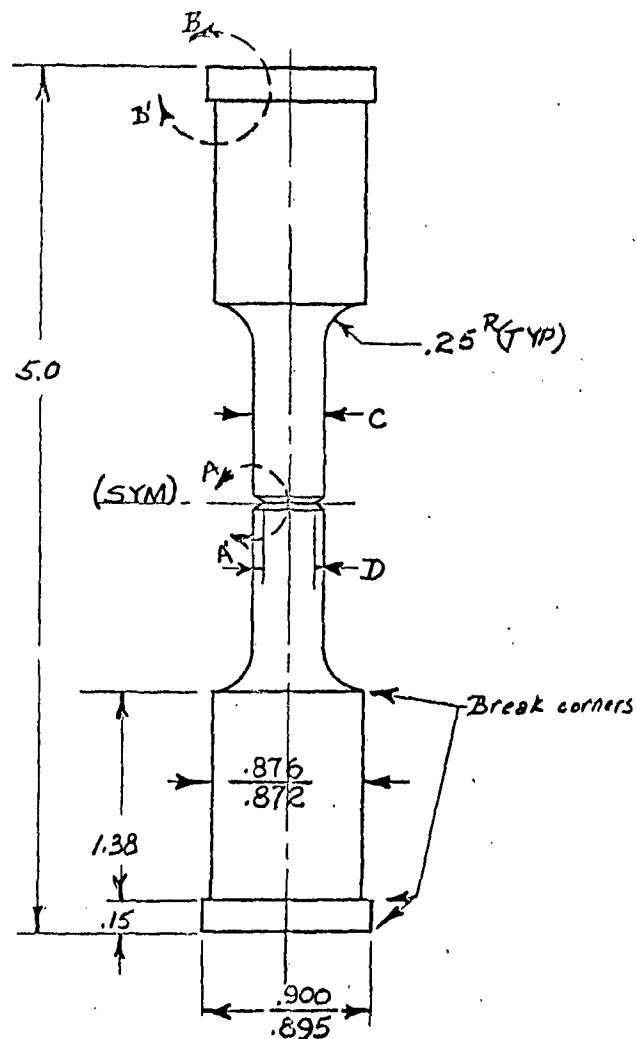
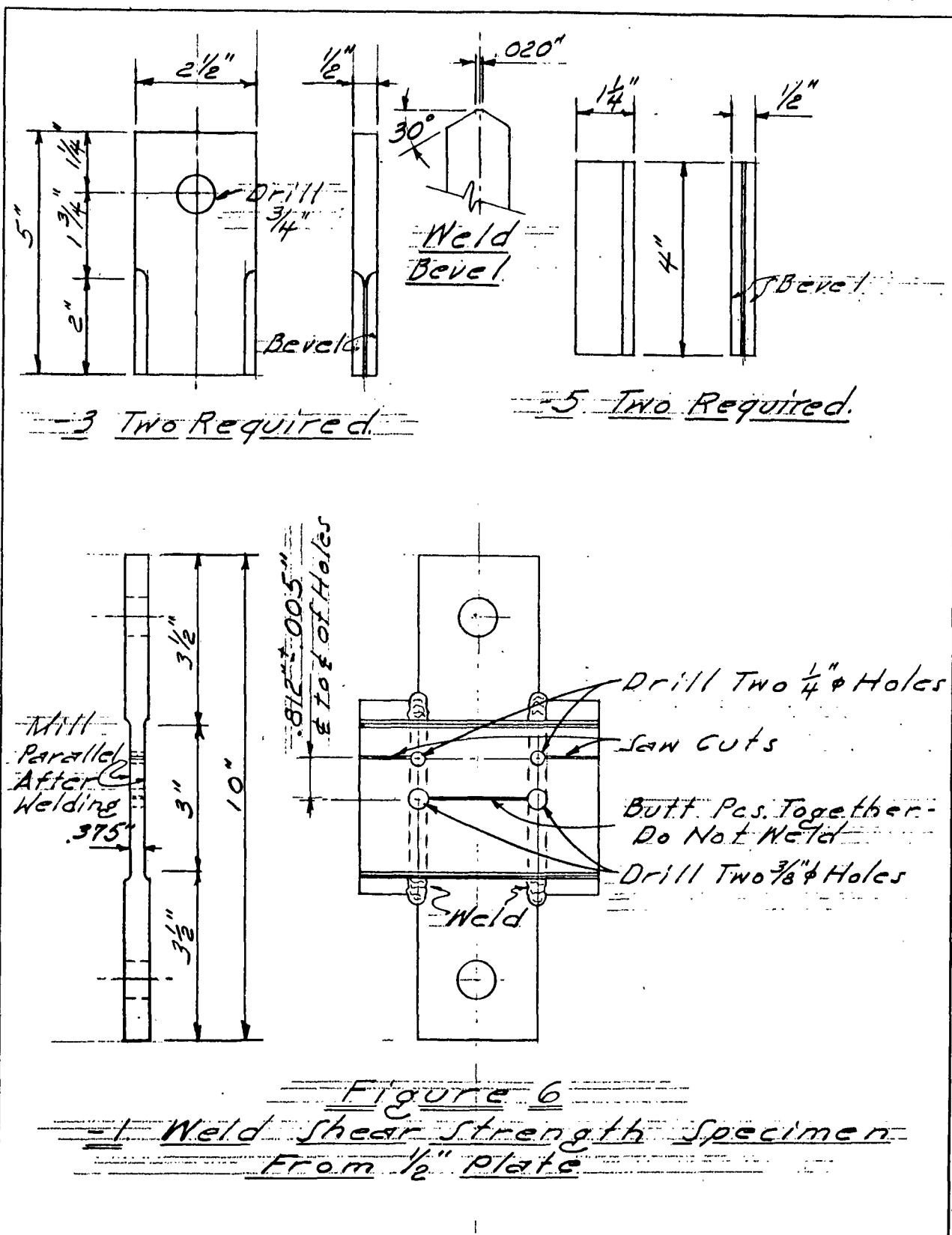
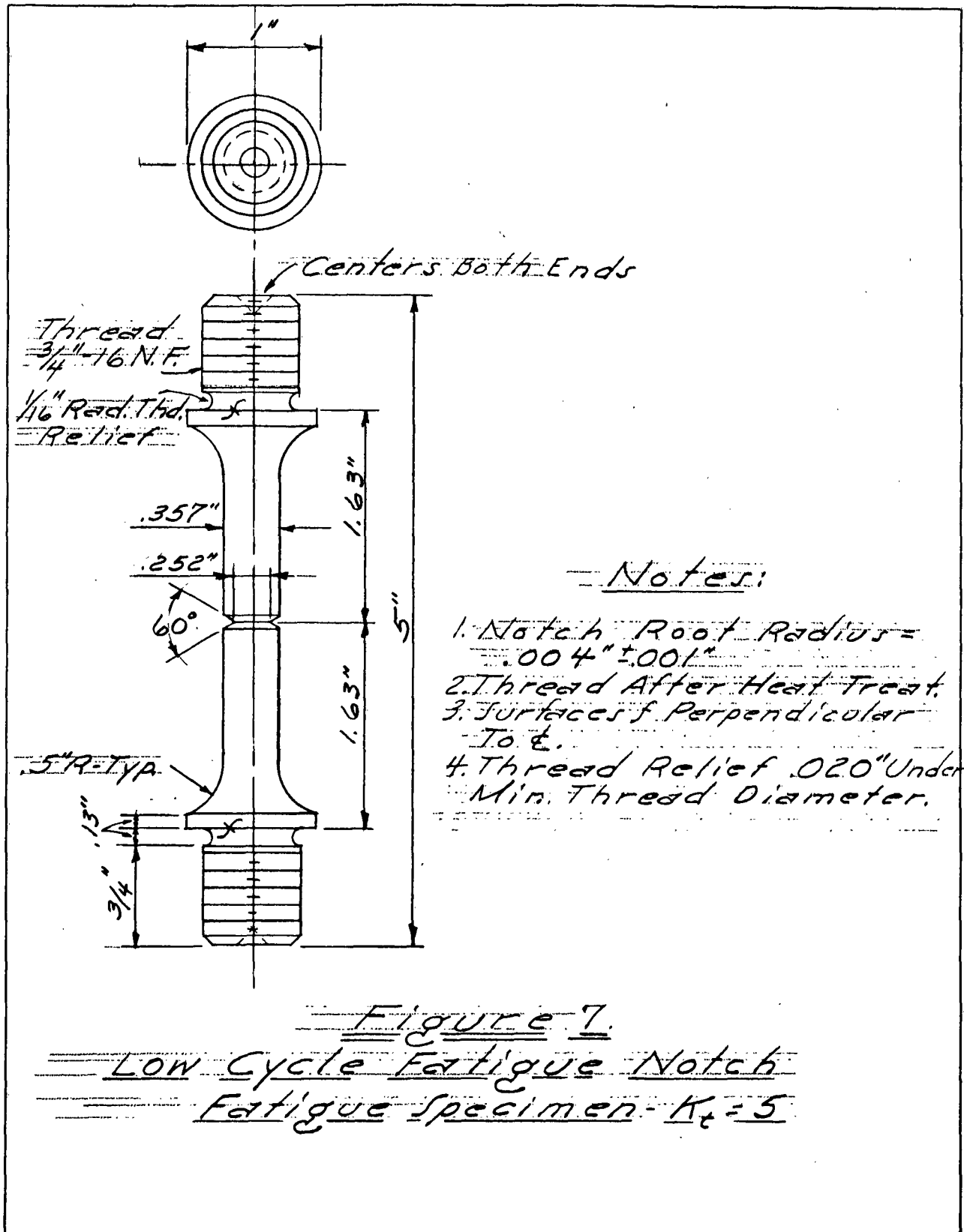


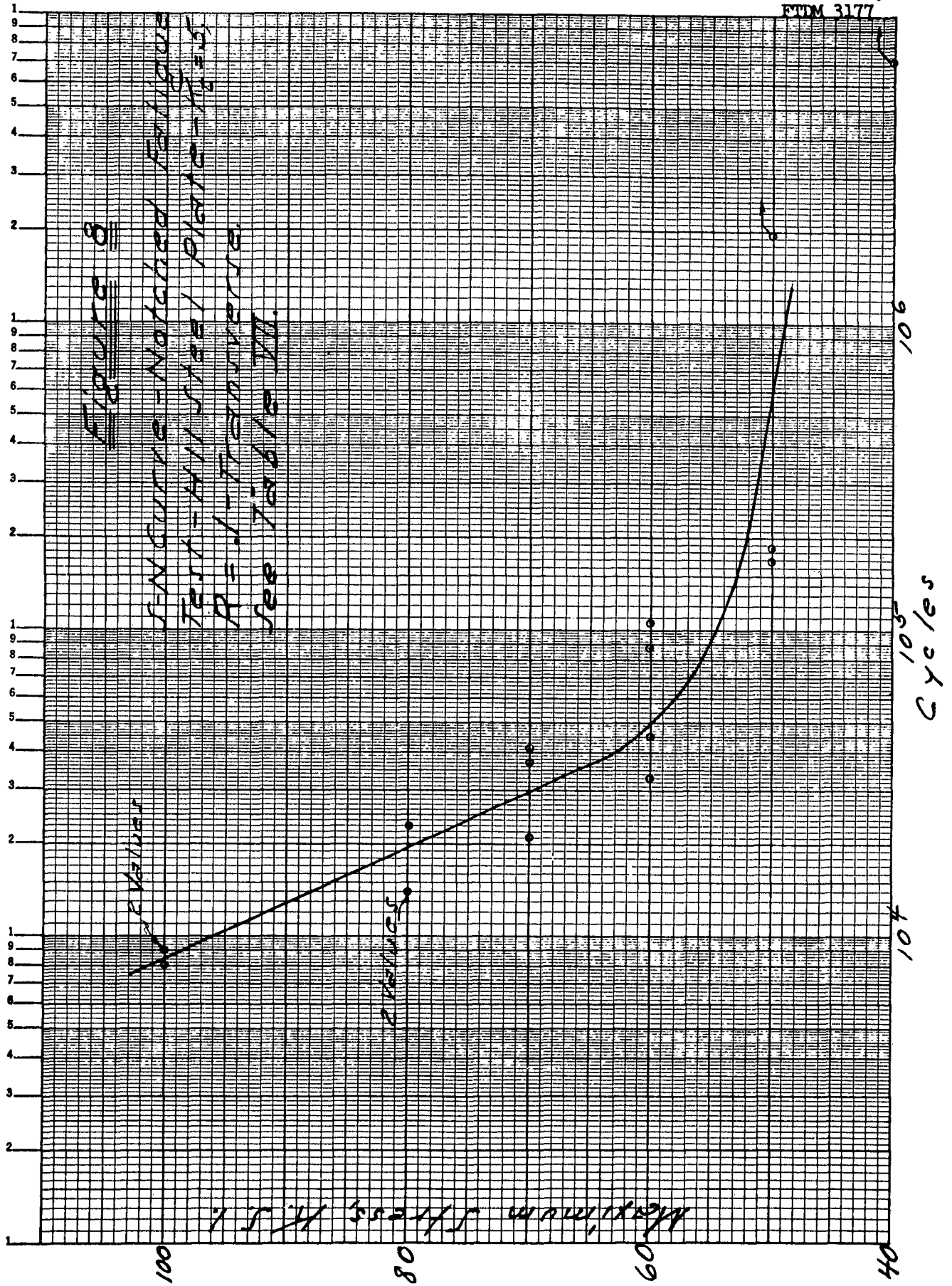
Figure 5.

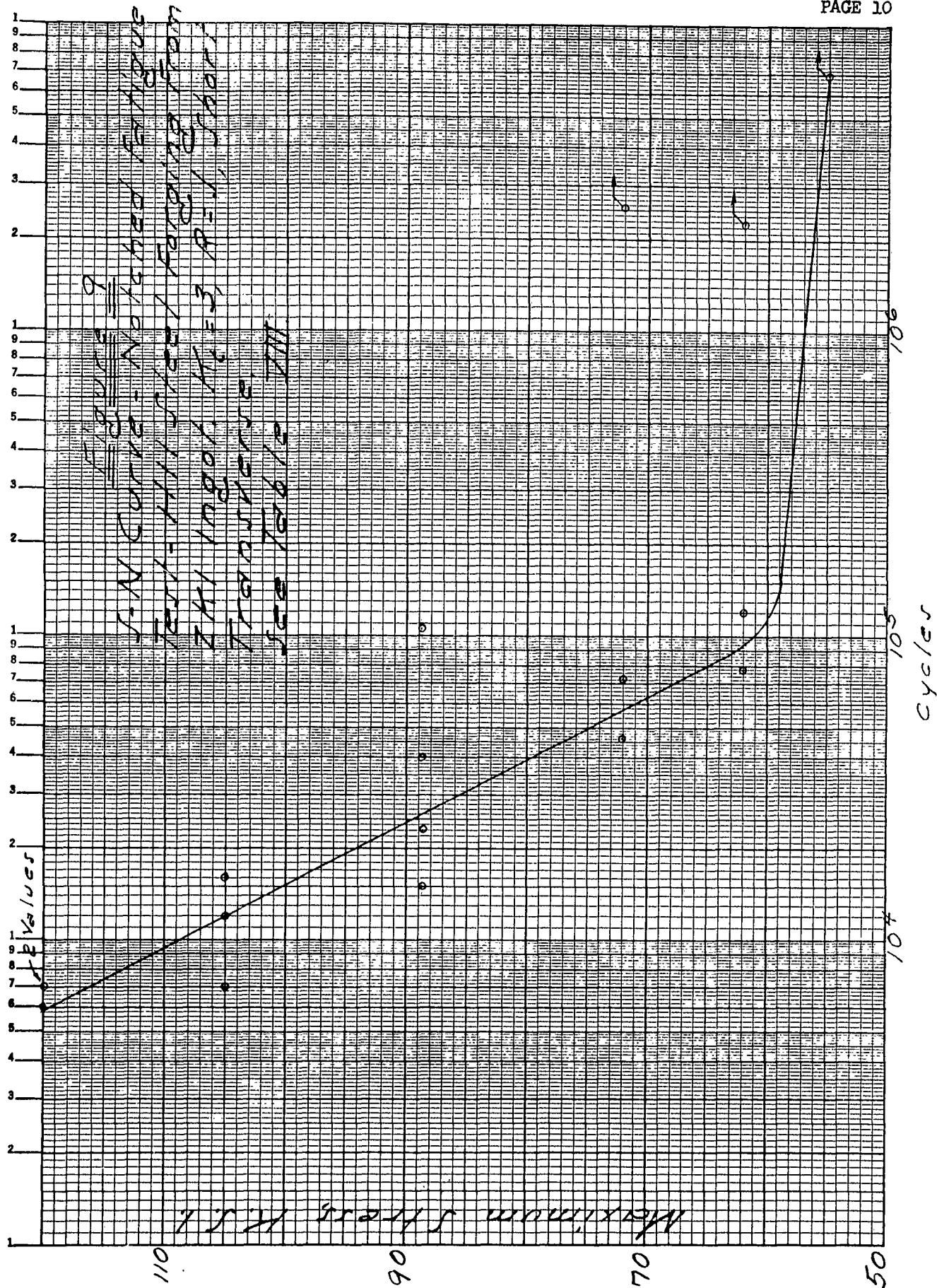
MAT'L		H'TREAT		Fatigue Test Specimen, $K_t > 1$ Collect Grip	TOOL NO. FTJ1094
TOL.	0.0 $\pm .10$	0.00 $\pm .030$	0.000 $\pm .010$		ANG. $\pm$
DRAWN R. G. Schilz		APPROVED		CONVAIR A DIVISION OF GENERAL DYNAMICS CORPORATION (FORT WORTH)	DEPT. 24 FW-32-0-24
CHECKED		DATE 31 Oct '63			

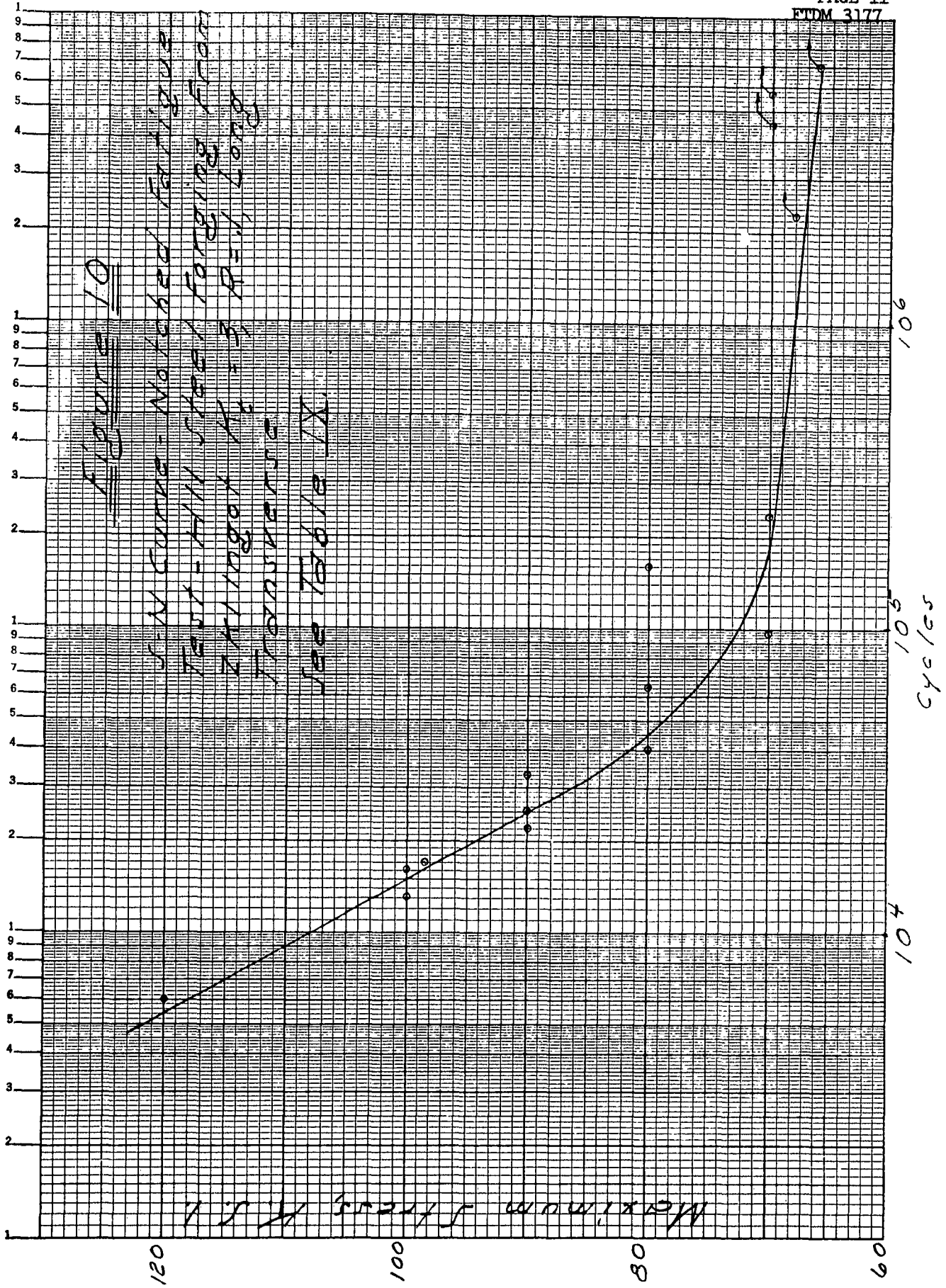












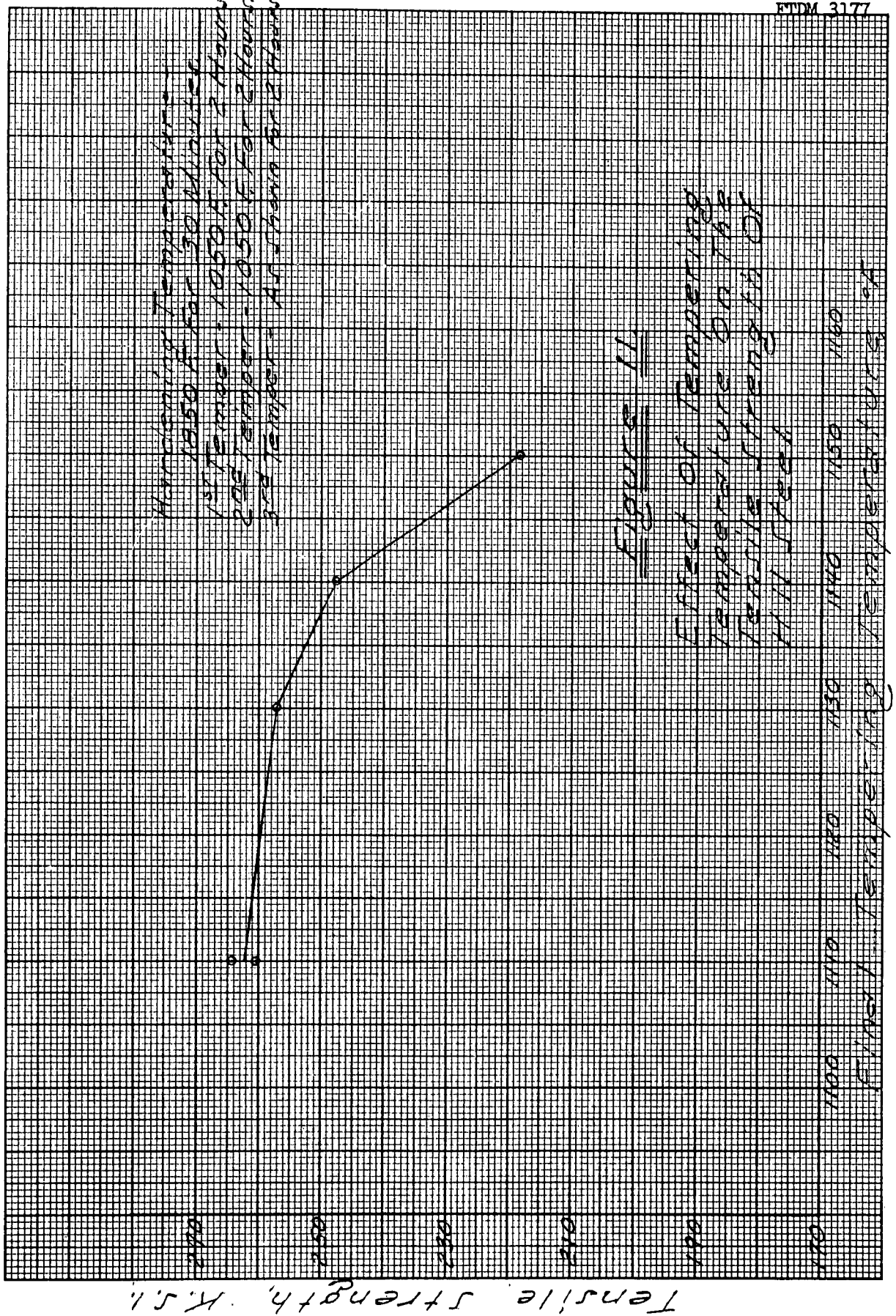




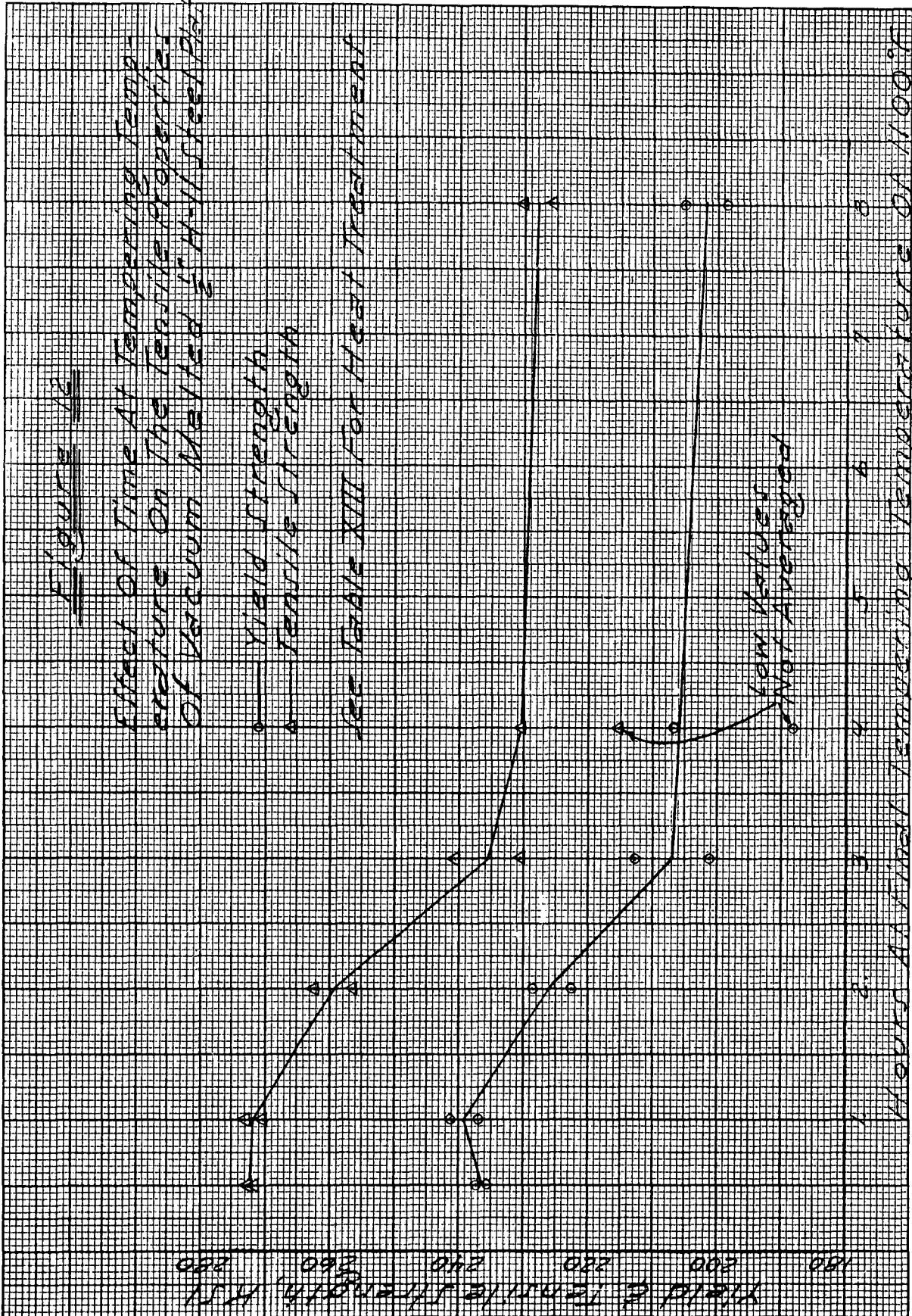
Figure 12

Effect of Time At Tempering Temp-  
erature On The Tensile Properties  
Of Vacuum Melted  $\frac{1}{2}$  H-11 Steel Bars

— Yield Strength  
— Tensile Strength

See Table XIII For Heat Treatment

Yield & Tensile Strength, KSI



**GENERAL DYNAMICS | FORT WORTH**

### TABLE I

He  
Con

\* All steels were vacuum melted

\*\* Forged From 8" RCS By Kropp Forging

1





**CONVAIR—FORT WORTH**

**TABULATION SHEET:**

TABLE II

Welding Data - Preparation Of Welded Test Specimens From  $\frac{1}{2}$ " H-11 Vac. Melted Steel Plate

Equipment - Mechanized T. I. G. Welding Machine.

Electrode - 2% Thoriated Tungsten,  $\frac{1}{8}$ "  $\phi$ , Point Ground  $T_3$   
60° Included Angle - #8 Ceramic Cup.

Shielding Gas - Argon, 25 cfh On Face, 15 cfh On Root.

Head Travel -  $3\frac{1}{2}$  inches Per Minute.

Preheat & Interpass Temperature - 300 To 400° F.

Filler Wire -  $\frac{1}{16}$ " Diameter H-11 Steel.

Number Of Passes Per Weld - 5, As Follows:

1 <sup>st</sup> Pass -	295 Amps, 10 Volts, 10" Filler Wire / Min.
2 <sup>nd</sup> Pass -	340 Amps, 10 Volts, 12" Filler Wire / Min.
3 <sup>rd</sup> Pass -	340 Amps, 10 Volts, 14" Filler Wire / Min.
4 <sup>th</sup> Pass -	365 Amps, 10 Volts, 17" Filler Wire / Min.
5 <sup>th</sup> Pass -	450 Amps, 10 Volts, 16" Filler Wire / Min.

Post Welding Treatment - Stress Relieve @ 1250° F  
For 2 Hours Immediately Following Welding.

MECHANICAL PROPERTIES OF HILL STEEL  
 4" x 12" x 30" BILLET - Vacuum Melted.

TABULATION SHEET TABLE III

Specimen No.	Harden- ing - Temp, °F.	1st		2nd		3rd		4th		Specimen Diam. Inches	FTY Lbs.	FTU Lbs.	FTU KSI	%Elong.	
		Temp, °F.	Direction	Temp, °F.	Direction	Temp, °F.	Direction	Temp, °F.	Direction						
3-1A	1850	Transv.	1050	1050	1130	—	—	—	—	.5020	46000	232.4	50900	257.2	6.0
3-1B					1140	—	—	—	—	.5070	45000	222.9	50050	247.7	6.5
3-34A					1150	—	—	—	—	.5037	38600	193.7	43500	218.3	9.0
3-34E					1110	—	—	—	—	.5021	46600	235.4	51500	260.1	7.0
3-34H					1110	—	—	—	—	.5062	47700	237.0	53200	264.3	6.0
3-34F					1110	1130				.5087	41100	202.2	47100	231.7	10.5
3-34D					1110	1125				.5076	42300	209.0	47400	234.2	7.0
3-34G					1110	1125				.5051	40800	203.6	46000	229.5	9.0
3-34B					1110	1140				.5039	38600	193.6	43100	216.2	11.0
3-34C					1110	1140				.5046	39700	198.5	43800	219.0	10.5
*	Hardening Temperatures & All Tempering Treatments Were 30 Minute Duration,														
Δ	Controls For Fracture Toughness Specimens # 3-25 Thru 3-33 & # 3-36														
○	Controls For Fracture Toughness Specimens # 3-15 Thru 3-24.														



TABLE V. Mechanical Properties of H11 Steel -  $\frac{1}{2}$ " Plate, Transverse Welded.

Specimen No.	Width, In.	Thick, In.	Area, Sq. In.	F <sub>TS</sub>	F <sub>TS</sub>	F <sub>TS</sub>	F <sub>TS</sub>	F <sub>TS</sub>	% Elong. 2" Gage
H3-8	4965	249	1236	25800	2087	28550	2310		5.0
H3-9	508	251	1275	26650	2090	29600	2322	8.0	4.5
H6-7	487	246	1198	24900	2078	26800	2237		5.0
H8-1	501	250	1253	24050	1919	26650	2127		5.0
H9-5	5005	236	1176	25400	2160	28250	2402		3.0
H10-9	497	243	1208	25700	2127	28550	2363	6.0	3.5
H11-8	499	2505	1250	26600	2128	29400	2352	6.0	3.5

## Heat Treatment:

Austenitizing: 1850 F 30 Min. Air Cool -  
Cool To Below 1300 F. in 3 Minutes.

1<sup>st</sup> Temper: 1075 F 2 Hrs.

2<sup>nd</sup> Temper: 1075 F 2 Hrs.

3<sup>rd</sup> Temper: 1110 F 3 Hrs.

**CONVAIR—FORT WORTH**

**TABULATION SHEET:**

## TABLE VII

Fatigue Properties Of H11 Steel-  
Welded  $\frac{1}{2}$ " plate-Vacuum Melted.  
T. R = 1 Transverse Welds.

Specimen No.	Thickness, Inches	Width, Inches	Max. Stress, K.S.I.	Cycles $\times 10^3$	Remarks.
H 7-7	.237	.500	180.	19.	Failed Out Of Reduced Section.
H 7-3	.2525	.500	180.	29.	Bearing Failure.
H 9-7	.247	.501	180.	28.	
H 11-6	.251	.501	180.	42.	Bearing Failure.
H 8-9	.211	.497	162.	555.	
H 9-6	.2416	.4785	160	32.	Defective.
Notes: See Table II For Welding Data.					
See Table II For Heat Treatment.					

CONVAIR—FORT WORTH  
TABULATION SHEET

TABULE VII

Notch Fatigue Test Results—  
4111 Steel Plate, 1" x 12" x 48",  
Transverse,  $R = .1$ ,  $R_2 = 5$

Specimen No.	Notch Dia. in.	Notch Radius Inches	Max. Stress	Cycles	Remarks
	Inches	Inches	ksi	x 10 <sup>3</sup>	
T-3.	.2528	.005	110.		Failed in Tension.
T-13.	.2527	.005	110.		Failed in Tension.
T-24.	.2535	.004	110.		Failed in Tension.
T-2.	.2495	.005	100.	9.	
T-11.	.2520	.005	100.	8.	
T-19.	.2545	.005	100.	9.	
T-1.	.2487	.005	80.	23.	
T-5.	.2520	.005	80.	14.	
T-10.	.2530	.0045	80.	14.	
T-15.	.2535	.0045	80.		Failed in Tension
T-8.	.2520	.004	70.	21.	
T-16.	.2525	.005	70.	41.	
T-25.	.2535	.0045	70.	37.	
T-4.	.2520	.005	60.	87.	
T-7.	.2530	.005	60.	107.	
T-9.	.2510	.004	60.	45.	
T-14.	.2520	.005	60.	33.	
T-6.	.2520	.005	50.	169.	
T-12.	.2535	.005	50.	186.	
T-21.	.2520	.0055	50.	1959.	Did Not Fail.
T-18.	.2510	.005	40.	7165.	Did Not Fail.

Notes: See Table VI For Heat Treatment

Notch Fatigue Test Results - H11  
Steel Forging From Z H1 Ingot  
TABULATION SHEET **TABLE VIII**  $H_c = 3$ ,  $R = 1$ , Short Transverse.

Specimen No.	Notch Diam.	Notch Radius	Max. Stress	Cycles	Remarks
	Inches	Inches	ksi	$\times 10^3$	
VE 15	.251	.013	120	6	
WE 10	.247	.014	120	7	
WE 7	.250	.014	120	7	
VE 6	.2485	.013	105	12	
WE 5	.247	.014	105	7	
VE 11	.251	.014	105	16	
WE 11	.2505	.014	88	15	
WE 13	.249	.014	88	23	
WE 8	.249	.014	88	40	
VE 8	.249	.014	88	105	
WE 9	.250	.013	72	46	
VE 13	.252	.013	72	73	
VE 14	.250	.014	72	2527	Did Not Fail
VE 16	.2495	.014	62	78	
VE 19	.248	.014	62	120	
WE 3	.251	.014	62	2247	Did Not Fail
VE 1	.250	.014	55	6933	Did Not Fail

Note: Steel Was Vacuum Melted.

See Table II For Heat Treatment



## TABLE IX

Notch Fatigue Test Results - H11  
Steel Forging From Z H1 Ingot,  
 $H_t = 3$ , R.R. Long Transverse

Specimen No.	Notch Diam.	Notch Radius	Max. Stress	Cycles $\times 10^3$	Remarks
	Inches	Inches	ksi		
WC-11	.252	.012	120		Failed on starting.
WC-9	.252	.012	120	6	
WC-6	.251	.013	100	13	
WC-12	.246	.013	100	16	
WC-7	.253	.012	98.5	17	
WC-17	.254	.014	90	25	
WC-4	.252	.014	90	22	
WC-5	.251	.014	90	33	
WC-8	.252	.013	80	64	
WC-7	.251	.014	80	159	
WC-8	.252	.0135	80	40	
WC-6	.249	.013	70	233	
WC-2	.252	.014	70	5616	Did Not Fail.
WC-4	.2475	.012	70	4455	Did Not Fail.
WC-16	.251	.013	70	96	
WC-14	.246	.013	68	2244	Did Not Fail.
WC-8	.257	.014	66	6878	Did Not Fail.

Note: Steel Was Vacuum Melted.

See Table II For Heat Treatment

## TABLE X.

Notch Fatigue Test Results -  
 H11 Steel Forging, ZHB Ingot -  
 $K_t = 5$ ,  $R = 1$ , Longitudinal

Specimen No.	Notch Diam.	Notch Radius	Max. Stress	Cycles	Remarks
	Inches	Inches	KSI	$\times 10^3$	
XA-10.	.2475	.005	100.	8.	
XA-2.	.252	.005	100.	6.	
XA-18.	.249	.005	72.	20.	
XA-6.	.249	.006	72.	43.	
XA-16.	.250	.005	72.	32.	
XA-9	.250	.006	50	4347	Did Not Fail.

Note: Steel Was Vacuum Melted.

See Table II For Heat Treatment.





CONVAIR—FORT WORTH

## TABULATION SHEET

## TABLE XIII.

Effect of Time At Tempering Temp-  
erature On The Tensile Properties Of  
Vacuum Melted  $\frac{1}{2}$ " H-11 Steel Plate.

Specimen No.	Grain Direction	Thick Temp. of F.	Thick Temp. Hours	Diam. Inches	F <sub>TS</sub> Lbs	F <sub>YS</sub> KSI	F <sub>TS</sub> Lbs	F <sub>YS</sub> KSI	F <sub>TS</sub> Lbs	F <sub>YS</sub> KSI	% Elong. 2" Gage
1	Long.	1100	$\frac{1}{2}$	.2544	12000	235.8	13840	271.9			12.0
2			$\frac{1}{2}$	.2532	11960	237.3	13740	272.6			12.0
3			1	.2513	11960	241.1	13540	273.0			11.0
4			1	.2531	11920	237.0	13600	270.4			12.0
5			2	.2538	11560	228.5	13260	262.1			13.0
6			2	.2540	11280	222.5	13000	256.4			13.0
7			3	.2518	10600	212.9	11980	240.6			13.0
8			3	.2521	10040	201.2	11500	230.5			14.0
9			4	.2521	10320	206.8	11500	230.4			12.0
10			4	.2531	9460	188.1	10820	215.1			15.0
11			8	.2513	9860	198.8	11200	225.8			16.0
12			8	.2536	10360	205.1	11620	230.1			12.0
Heat Treatment:											
Austenitizing - 1850°F - 30 Minutes - Air Cool											
First Temper - 1075°F - 2 Hours.											
Second Temper - 1075°F - 2 Hours.											
Third Temper - As Listed Above.											